

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) A single slit forms a diffraction pattern, with the first minimum at an angle of 40° from central maximum. Monochromatic light of 450-nm wavelength is used. The same slit, illuminated by a different monochromatic light source, produces a diffraction pattern with the second minimum at a 60° angle from the central maximum. The wavelength of this light, in nm, is closest to:
A) 375 B) 357 C) 303 D) 321 E) 339 1) _____
- 2) A single slit forms a diffraction pattern, with the first minimum at an angle of 40° from central maximum. Monochromatic light of 640-nm wavelength is used. The width of the slit, in nm, is closest to:
A) 996 B) 914 C) 955 D) 873 E) 832 2) _____
- 3) A single slit, 2300 nm wide, forms a diffraction pattern when illuminated by monochromatic light of 460-nm wavelength. The largest angle from the central maximum at which the intensity is zero is closest to:
A) 84° B) 78° C) 81° D) 87° E) 90° 3) _____
- 4) A single slit, 1500 nm wide, forms a diffraction pattern when illuminated by monochromatic light of 620-nm wavelength. At an angle of 10° from the central maximum, the phase angle between wavelets originating at the far edge of the slit, relative to wavelets originating at the near edge, is closest to:
A) 2.0 rad B) 2.6 rad C) 1.3 rad D) 4.0 rad E) 3.3 rad 4) _____
- 5) A single slit, 2300 nm wide, forms a diffraction pattern when illuminated by monochromatic light of 660-nm wavelength. At an angle of 10° from the central maximum, the ratio of the intensity to that of the central maximum is closest to:
A) 0.33 B) 0.25 C) 0.41 D) 0.29 E) 0.37 5) _____
- 6) A single slit forms a diffraction pattern with monochromatic light. The 6th minimum of the pattern occurs at an angle of 23° from the central maximum. The number of bright bands on either side of the central band is closest to:
A) 16 B) 13 C) 14 D) 15 E) 17 6) _____
- 7) A single slit forms a diffraction pattern with monochromatic light. The fourth minimum of the pattern occurs at an angle of 25° from the central maximum. The angle at which the fifth minimum of the pattern occurs is closest to:
A) 31.4° B) 32.9° C) 31.9° D) 32.4° E) 30.9° 7) _____
- 8) An 18 mm wide diffraction grating has rulings of 690 lines per mm. Light is incident normally on the grating. Monochromatic light of 554 nm wavelength is used. The largest angle from the normal at which an intensity maximum is formed is closest to:
A) 50 B) 46 C) 48 D) 42 E) 44 8) _____

- 9) An 2.5-mm wide diffraction grating has rulings of 830 lines per mm. Light is incident normally on the grating. Two spectral lines have wavelengths close to 577-nm and the difference in their wavelengths is small. The smallest difference in the wavelengths of the two spectral lines that can be resolved by the grating in the highest order is closest to: 9) _____
 A) 0.6 B) 0.7 C) 0.3 D) 0.1 E) 0.4
- 10) An 11-mm wide diffraction grating has rulings of 890 lines per mm. Light is incident normally on the grating. The longest wavelength that forms an intensity maximum in the fifth order is closest to: 10) _____
 A) 275 nm B) 300 nm C) 200 nm D) 225 nm E) 250 nm
- 11) The spacing of ruled lines on a diffraction grating is 2010 nm. The grating is illuminated at normal incidence with a parallel beam of white light in the 400-nm to 700-nm wavelength band. The angular width of the gap between the first-order spectrum and the second-order spectrum is closest to: 11) _____
 A) 2.1° B) 4.1° C) 3.1° D) 6.1° E) 5.1°
- 12) The spacing of ruled lines on a diffraction grating is 2080 nm. The grating is illuminated at normal incidence with a parallel beam of white light in the 400-nm to 700-nm wavelength band. The second-order spectrum and the third-order spectrum overlap. The angular width of the overlap is closest to: 12) _____
 A) 3.1° B) 7.1° C) 6.1° D) 5.1° E) 4.1°
- 13) The spacing of ruled lines on a diffraction grating is 1790 nm. The grating is illuminated at normal incidence with a parallel beam of white light in the 400-nm to 700-nm wavelength band. The longest wavelength that appears in the third-order spectrum is closest to: 13) _____
 A) 577 nm B) 617 nm C) 557 nm D) 597 nm E) 537 nm

Situation 36.1

A metallic sheet has a large number of slits, 5.0 mm wide and 20 cm apart, and is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the grating.

- 14) In Situation 36.1, the microwave wavelength is 6.0 cm. The largest angle from the normal, at which an intensity maximum occurs, is closest to: 14) _____
 A) 69° B) 84° C) 74° D) 79° E) 64°
- 15) In Situation 36.1, the smallest microwave frequency for which only the central maximum occurs is closest to: 15) _____
 A) 1.5 GHz B) 1.0 GHz C) 0.7 GHz D) 0.5 GHz E) 2.0 GHz
- 16) In Situation 36.1, intensity maxima occur two degrees apart in the central region. The wavelength of the microwaves is closest to: 16) _____
 A) 6 mm B) 5 mm C) 9 mm D) 7 mm E) 8 mm

- 17) When monochromatic light passes through a pair of identical thin parallel slits, you observe on a distant screen that the eighth-order bright fringe due to double-slit interference is missing because it was cancelled by the third-order single-slit dark fringe. The ratio of the width of the slits to the distance between them is closest to: 17) _____
 A) 2.67 B) 0.375 C) 0.188 D) 5.33 E) 0.750
- 18) A laser beam passes through a thin slit. When the pattern is viewed on a screen 1.25 m past the slit, you observe that the fifth-order dark fringes occur at ± 2.41 cm from the central bright fringe. The entire experiment is now performed within a liquid, and you observe that each of the fifth-order dark fringes is 0.790 cm closer to the central fringe than it was in air. The index of refraction of this liquid is closest to: 18) _____
 A) 1.40 B) 1.49 C) 1.62 D) 1.33 E) 3.05
- 19) If the intensity of the central maximum in a single slit diffraction pattern has intensity I_0 , what is the approximate intensity of the first secondary maximum? 19) _____
 A) $0.045 I_0$ B) $0.25 I_0$ C) $0.50 I_0$ D) $0.090 I_0$ E) $0.22 I_0$

Situation 36.2

Certain planes of a crystal of halite have a spacing of 0.399 mm. The crystal is irradiated by a beam of x-rays. First order constructive interference occurs when the beam makes an angle of 20° with the planes.

- 20) In Situation 36.2, the wavelength of the x-rays, in nm, is closest to: 20) _____
 A) 0.27 B) 0.14 C) 0.21 D) 0.17 E) 0.24
- 21) In Situation 36.2, the angle the beam makes with the planes for second-order constructive interference to occur is closest to: 21) _____
 A) 49° B) 37° C) 46° D) 43° E) 40°
- 22) A diffraction grating has 450 lines per mm. What is the highest order that contains the entire visible spectrum from 400 nm to 700 nm? 22) _____
 A) $m = 2$ B) $m = 4$ C) $m = 6$ D) $m = 3$ E) $m = 5$

Situation 36.3

A thin beam of laser light of wavelength 514.0 nm passes through a diffraction grating having 3952 lines/cm. The resulting pattern is viewed on a distant semicircular screen that can show all bright fringes up to and including $\pm 90.0^\circ$ from the central spot.

- 23) In Situation 36.3, the *total* number of bright fringes that will show up on the screen is: 23) _____
 A) 4 B) 8 C) 5 D) 9 E) 10
- 24) In Situation 36.3, the two bright fringes most distant from the central bright fringe occur at angles away from the central spot that are closest to: 24) _____
 A) $\pm 11.7^\circ$ B) $\pm 90.0^\circ$ C) $\pm 54.3^\circ$ D) $\pm 84.5^\circ$ E) $\pm 66.1^\circ$
- 25) In Situation 36.3, if the experiment were performed with all of the apparatus under water (which has an index of refraction of 1.33), the *total* number of bright spots would be: 25) _____
 A) 14 B) 6 C) 13 D) 12 E) 7

- 26) A light beam shines through a thin slit and illuminates a distant screen. The central bright fringe on the screen is 1.00 cm wide, as measured between the dark fringes that border it on either side. Which of the following actions would *decrease* the width of the central bright fringe? (There may be more than one correct choice.) 26) _____
- A) decrease the width of the slit
 - B) increase the width of the slit
 - C) increase the wavelength of the light
 - D) decrease the wavelength of the light
 - E) put the apparatus all under water
- 27) A camera set with f -number $f/4$ has a focal length of 50 mm. What is the minimum spacing of two objects positioned 12 meters from the lens if the objects are barely resolved in the image? Assume the light wavelength is 500 nm. 27) _____
- A) 4.72 mm
 - B) 0.58 mm
 - C) 1.66 mm
 - D) 4.9×10^{-5} m
 - E) 0.024 mm
- 28) Which of the following does not accurately describe a hologram? 28) _____
- A) The light used to form the hologram must be coherent.
 - B) It forms a true three-dimensional image of an object.
 - C) The hologram image looks the same when viewed from all perspectives or directions.
 - D) It is a photographic image of an interference pattern.
 - E) It must be viewed with light of the same wavelength as that used to make the hologram.

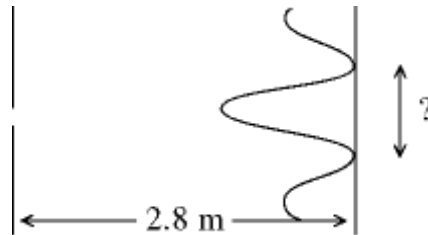
Situation 36.4

A camera used for aerial surveillance has a lens with a 30-cm maximum aperture and a 42-cm focal length. Assume light of 550-nm wavelength is used and that the resolution of the camera is limited solely by diffraction.

- 29) In Situation 36.4, the angular resolution of the camera at maximum aperture, in mrad, is closest to: 29) _____
- A) 3.2
 - B) 2.2
 - C) 6.3
 - D) 4.5
 - E) 1.6
- 30) In Situation 36.4, the lens has a minimum aperture of 3.8 cm. For this aperture, the radius of the Airy disk in the focal plane is closest to: 30) _____
- A) $1.9 \mu\text{m}$
 - B) $3.7 \mu\text{m}$
 - C) $5.2 \mu\text{m}$
 - D) $2.6 \mu\text{m}$
 - E) $7.4 \mu\text{m}$

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

Figure 36.1



- 31) In Fig. 36.1, a slit 0.3×10^{-3} m wide is illuminated by light of wavelength 426 nm. A diffraction pattern is seen on a screen 2.8 m from the slit. What is the linear distance on the screen between the first two diffraction minima on either side of the central diffraction maximum? 31) _____
- 32) A diffraction grating is to be used to find the wavelength of the emission spectrum of a gas. The grating spacing is not known, but a light of a known wavelength of 632.8 nm is deflected by 43.2° in the second order by this grating. Light of the wavelength to be measured is deflected by 35.5° in the second order. What is the wavelength of this light? 32) _____
- 33) Treat each of your eyes as a circular aperture of diameter 3.5 mm. Light of wavelength 500 nm is used to view two point sources that are 894 m distant from you. How far apart must these two point sources be if they are to be just resolved by your eye? Assume that the resolution is diffraction limited and use Rayleigh's criterion. 33) _____
- 34) In a diffraction pattern produced by a single slit, the phase angle β (the phase difference between wavelets from the top and bottom of the slit) is 3.90π rad at an angle of 0.770° from the central maximum. If the light used has a wavelength of 555 nm, find the slit width. 34) _____
- 35) A researcher is investigating a cubic crystal with x-rays. He is looking at Bragg reflection from the planes parallel to the cube faces. He finds that when using x-rays of 0.165 nm a strong first maximum occurs when the beam makes an angle of 23.5° with the planes. What is the spacing of adjacent atoms in the crystal? 35) _____
- 36) A thin beam of light of wavelength 625 nm goes through a thin slit and falls on a screen 3.00 m past the slit. You observe that the first completely dark fringes occur on the screen at distances of ± 8.24 mm from the central bright fringe, and that the central bright fringe has an intensity of 2.00 W/m^2 at its center. \ 36) _____
 (a) How wide is the slit?
 (b) Calculate the intensity of light at a point on the screen that is one-quarter of the way from the central bright fringe to the first dark fringe.

Answer Key

Testname: UNTITLED5

- 1) C
- 2) A
- 3) E
- 4) B
- 5) B
- 6) C
- 7) C
- 8) A
- 9) D
- 10) D
- 11) C
- 12) B
- 13) D
- 14) E
- 15) A
- 16) D
- 17) B
- 18) B
- 19) A
- 20) A
- 21) D
- 22) D
- 23) D
- 24) C
- 25) C
- 26) B, D, E
- 27) B
- 28) C
- 29) B
- 30) E
- 31) $8.0 \times 10^{-3} \text{ m}$
- 32) 537 nm
- 33) $1.6 \times 10^{-1} \text{ m}$
- 34) $8.05 \times 10^{-5} \text{ m}$
- 35) 0.207 nm
- 36) (a) 0.228 mm (b) 1.62 W/m²

- 1) _____
- 2) _____
- 3) _____
- 4) _____
- 5) _____
- 6) _____
- 7) _____
- 8) _____
- 9) _____
- 10) _____
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- 26) _____
- 27) _____
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- 29) _____
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- 31) _____
- 32) _____
- 33) _____
- 34) _____
- 35) _____
- 36) _____